Chapter 2

Climate change and Brazilian agriculture

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Introduction

Anthropogenic greenhouse gas (GHG) emissions and land use and land cover changes are expected to impact global climate in the coming decades (Intergovernmental Panel on Climate Change, 2013). For example, increasing global average temperature, average sea level and the frequency and intensity of rainfalls and drought, causing floods and heat waves, are expected as results of anthropogenic activities. Such changes should significantly impact a number of agroecosystems across the globe (Stocker et al., 2013; Stevanović et al., 2016; Moore et al., 2017; Zhao et al., 2017; Scott et al., 2018).

As population grows and consumption of food, fiber and biofuels increase, the agricultural sector will face enormous challenges to maintain production growth and to adapt to climate change (Stevanović et al., 2016). Particularly in Brazil, the demand for exports has placed the country as one of the main agricultural producers in the world. Agriculture plays a prominent role in Brazilian Gross Domestic Product (GDP), and amounts to 23% of industrial GDP and 42% of exports (Escola Superior de Agricultura Luiz de Queiroz, 2018), and creates 37% of direct and indirect jobs in Brazil. In turn, the Brazilian sector of planted trees, with an area of 7.84 million hectares of reforestation, is responsible for 91% of all wood for industrial purposes and 6.2% of the industrial GDP of Brazil. Unlike countries at high latitudes, agricultural commodity exporters in tropical regions, such as Latin America, are expected to experience more severe climate change impacts on crop yields, and consequently losses in consumer surplus may exceed potential gains in producers surplus, which may reflect on higher prices (Stevanović et al., 2016).

Therefore, Brazilian agroecosystems will have to seek technological innovations that simultaneously allow mitigating GHG emissions and adapting to climate change, in order to guarantee production of food to its current and future populations in the medium and long terms, as well as income generation from commodity exports, especially of higher added value agroindustry products.

Direct impacts

Climate is the main environmental factor associated with production variability in agriculture, especially for rainfed systems, which occupy large areas in Asia and most of the agricultural areas in Africa and Latin America (Hijmans; Serraj, 2008). Climatic risks that potentially cause significant or total production loss can be divided into two groups: those related to extreme events (e.g. low and high temperatures, intense rainfalls and strong winds, among others) and those related to cumulative events (e.g. long droughts, temperatures limiting growth for long periods, etc.). Recent studies have emphasized that, while changes in average climate conditions affect agricultural productivity and require adaptation policies, most agricultural crop losses and food security risks will be associated with increasing annual variations of climatic conditions thanks to extreme climatic events (Alexander et al., 2006; Stevanović et al., 2016). For example, drought in the central region of Brazil in 2016 caused a rise in maize grain prices and its supply shortage in some Brazilian regions. By the end of 2016, 39.6 million tons of corn were harvested, 29.5% less than in the previous year (56.3 million tonnes), despite a 10.3% increase in planted area (Produção Agrícola Municipal, 2018). Additionally, 3 years of rainfall below the historical average in the Southeastern region damaged around 100 thousand hectares of eucalyptus forest, leading to losses of 10 million cubic meters of wood between 2013 and 2015.

Research, development and innovation efforts have been seeking solutions so that increasingly sustainable agriculture can adapt to climate change impacts and mitigate GHG emissions. Economic, social and environmental feasibility of technologies for sustainable development is fundamental to reduce social inequalities and to guarantee food and water security for all, like the Circular Economy (Stahel, 2016). Advancing scientific and technological knowledge in recent years and promoting education and research institutions interaction play a fundamental role in the proposition and successful adoption of public policies to increase the adaptive capacity to face climatic risks, thus creating opportunities and opening paths for climatic resilience. Adapting agriculture to Circular Economy creates opportunities to mitigate GHG emissions in more productive and socioenvironmentally-efficient agroecosystems (Stahel, 2016). This is why strengthening actions to reduce climate-change-inherent impacts and risks, creating opportunities in low carbon economy and promoting sustainability in the rural environment are crucial.

Indirect impacts

Climate change may have many indirect impacts on plant stress in ecosystems and agroecosystems. Another great impact on crop productivity over the next decades can be the effect of increasing atmospheric CO_2 partial pressure on plant photosynthesis, especially C3 ones (e.g., wheat, rice and soy), and on the nutritional value of plant-based foods. Recent results have indicated that non-legume C3 crops have lower protein concentrations when grown in a high CO_2 concentration environment, while C4 crops appear to be less affected (Myers et al., 2014). These effects on productivity and quality of plants have been highlighted in Embrapa research agenda. For example, atmospheric CO_2 excess may eventually benefit irrigated rice yield in the state of Rio Grande do Sul, the main producing state of Brazil (Cuadra et al., 2015).

Climate change may intensify abiotic as well as biotic stresses. For example, it is extremely important to estimate how plant pathology problems can be affected by climate changes, since pathogens and pests cause drastic productivity reductions and may jeopardize the economic and environmental sustainability of various agricultural activities. In the case of animal production, the incidence of ectoparasites, such as ticks, a very common health problem in livestock, may increase. However, adaptation measures can only be incorporated after knowledge on the relations between climatic elements and distribution of plant diseases in time and space has been produced. In this sense, several simulation (models) and experimentation studies have been carried out in recent years (Pereira, 2008; Bettiol et al., 2017).

Impacts of agriculture on climate change

Agriculture will not only be affected by climate change, but may contribute to its intensification; therefore, ways to mitigate agricultural GHG emissions must be developed. The scientific community has agreed to the term Low Carbon Emission Agriculture (ABC), which aims to encourage the adoption of a set of actions and technologies to mitigate GHG emissions, combining CH_4 (methane), N_2O (nitrous oxide), and CO_2 (carbon dioxide), or to sequester atmospheric CO_2 in vegetation and soils. ABC occurs in agroecosystems in which plant and animal biotechnology, chemical engineering and mechatronics are gradually integrated, thus promoting better productivity rates and material recycling processes, whether or not associated with generation of renewable energy (biomass, biodiesel, biogas, etc.). Among these, combinations of integrated plant-animal systems, no-tillage with crop rotation and cover crops / green manure, Biological Nitrogen Fixation (BNF) and improved pastures are prominent examples (Sacramento et al., 2013; Brandão et al., 2017). Mitigating emissions through agricultural integration and intensification in agroecosystems allows the conservation of natural resources and provides environmental services from remaining ecosystems (Silva et al., 2015). Combinations of agricultural technologies and practices that favor enhanced productivity gains and certified mitigation of GHG emissions should be priorities.

In addition to producing commodities and food, Brazilian paper, pulp and biofuel industries occupy an outstanding position. Along with photovoltaic and wind power, energy crops are viable economic and environmental alternatives for the gradual replacement of fossil energy sources for renewable energy, mainly for the transportation sector. Several crops have been used for producing varied types of biofuels, such as ethanol from sugar cane and corn, biodiesel from soybean, and biomethane and biokerosene from animal waste. The forestry sector, in turn, has great potential for GHG reduction by promoting carbon sequestration in commercial tree plantations (for non-energy purposes) and by recovering Legal Reserves, Permanent Protection Areas and Private Reserves of Natural Heritage, in order to comply with the Forestry Code and the Rural Environmental Registry.

Conservation of ecosystem services

The opportunity to leverage Circular Economy technologies for emission mitigation and agricultural adaptation to climate change should trigger the conservation of natural resources and safeguarding the provision of environmental services from agroecosystems in Brazil. Agroecosystems provide various ecosystem services, such as regulation of soil and water quality, carbon sequestration, maintenance of biodiversity and insect pollinators or pest controllers, as well as cultural services (Power, 2010). These services include the “blue water” cycle, which is responsible for forming rivers, and “green water”, which represents the interaction of rainfall water and terrestrial ecosystems, giving rise to evapotranspiration, percolation and recharging of subterranean aquifer processes (D'Odorico et al., 2010). In this context, one of the main ecosystem services is water resources.

Climate change may affect water resources in a number of ways in Brazil. In the northeastern Semi-arid region, increased water demand due to increased evapotranspiration and reduced rainfall, thus enhancing a desertification-like process, is expected (Cavalcanti et al., 2005; Gondim et al., 2012). In turn, climate change has been increasing extreme rainfall events in the Pantanal (Bergier et al., 2018). Under pressure from expanding urban areas and advancing large-scale agribusiness in rural areas, many human populations have been migrating and settling in peripheral and other areas intrinsically more vulnerable to climate change. There are also indications that climate change could increase the number of asylum applications (refugees from climate change) in developed and developing countries (Missirian; Schlenker, 2017). These vulnerable populations will increasingly need support and public policies that create opportunities to reintegrate them into society or enable them to migrate and resettle in safer regions.

Public policies

The Política Nacional de Mudanças Climáticas (National Policy on Climate Change – PNMC) made official the voluntary commitment of Brazil to the United Nations Framework Convention on Climate Change (UNFCCC) to reduce between 36.1% and 38.9% of its projected GHG emissions by 2020. Presidential Decree nº 7.390/2010 (Brasil, 2010) regulates the PNMC and sets GHG emission baseline for 2020 at 3.2 Gt CO_2-eq (1 Gt = 10^9 tons of CO_2 equivalent). Therefore, the corresponding absolute mitigation commitment is between 1.2 Gt CO_2-eq and 1.3 Gt CO_2-eq. In 2012, agriculture accounted for 37% of national emissions. From 2005 to 2012, agricultural emissions increased by 7.4%, from 415.7 Gg CO_2-eq to 446.4 Gg CO_2-eq (1 Gg = 10^9 grams or 10^3 tons of CO_2 equivalent). However, from 1995 to 2005, agricultural emissions had increased, from 335.8 Gg CO_2-eq to 415.7 Gg CO_2-eq, that is, a 23.8% increase. In land use and forestry sectors, 1990 emissions (815.96 Gg CO_2-eq) increased by 138% in 1995 (1,940.42 Gg CO_2-eq), coinciding with the peak of deforestation in the Amazon. Public monitoring and control policies to contain the progress of deforestation have been very successful and effective, thus bringing emissions to 175.7 Gg CO_2-eq in 2012, a 91% reduction in relation to 1995 figures. In addition to the PNMC, the federal government established sectoral strategies, such as the ABC Plan (Plano..., 2012) and the Plano Nacional de Adaptação (National Adaptation Plan – PNA). Embrapa has proactively joined by means of doing research, developing new technologies and supporting the design of these public policies for emission mitigation and adaptation to climate change.

Process integration as agricultural response

Mitigating emissions and adapting to climate change essentially require the efficient and integrated use of natural resources available on a rural property, thus maximizing land potential, low impact on natural resources and, preferably, local generation of renewable energy. Currently, the Nexus approach, which links energy, water and food sectors in agriculture, as proposed by the Food and Agriculture Organization (FAO) of the United Nations (Flammini et al., 2014), has been increasingly adopted. FAO has developed Nexus to inform and guide decision-making and public policy-making processes to improve the socio-environmental and economic conditions of nations, thus offering participatory support for countries in designing and implementing such actions. Embrapa research and development studies related to agricultural emission mitigation and adaptation to climate change are adherent to FAO water-energy-food Nexus. Given that energy, water and food management are closely connected, they must be managed and governed in an integrated way to effectively meet the needs of a growing world population.

Final considerations

Agriculture is fundamental for Brazilian economy and food security. It is a worldwide consensus that financial gains and food from tropical agroecosystems are threatened by worsening climate change in the coming decades. However, deforestation and inadequate use of deforested areas for food production significantly contribute for this increase due to GHG emissions. Several public policies adopted in the last 20 years have been helping to mitigate Brazilian emissions from deforestation, particularly in the Amazon and Brazilian savanna (Cerrado), and to encourage the adoption of more sustainable technologies and productive arrangements. Embrapa research, development and innovation efforts, in partnership with other research centers and private companies, have resulted in major contributions and advances in designing these policies.

Given that most GHG emissions originate from burning fossil fuels, it is realistic to expect that the average temperature of the planet exceeds the +2 ºC threshold, even if Annex I countries achieve their emission reduction targets. In this case, the need to adapt agroecosystems to climate change is fundamental.

Therefore, Brazil needs to take immediate action to strengthen public and private partnerships that allow significant advances in knowledge. These advances must necessarily be translated into technologies aimed at simultaneously increasing agricultural productivity and environmental services (water production, carbon sequestration, biodiversity, etc.) from agroecosystems already established in different biomes, thus avoiding further deforestation. Embrapa will certainly play a leading role in these actions, thanks to its nationwide reach and its ability to weave large collaboration networks in an increasingly open and more competitive economy (Brasil, 2018).

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